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Essay

A critical review of the technology-inequality debate

*Francesco Bogliacino**

Phd, Profesor Facultad de Ciencias Económicas, Universidad Nacional de Colombia, Fundación Universitaria Konrad Lorenz, Bogotá, Colombia

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A B S T R A C T

In the last decades of the 20th Century, a large consensus emerged over the effect of technological change on wage distribution. The core of this theory becomes the backbone of a scientific paradigm that attempts to give an explanation for most of the open issues in currently developed economies, from rising of inequality in the USA to European unemployment, and from the different patterns of productivity to the institutional change. The dawn of this wisdom is reviewed, as well as the research program that consolidated it, with particular focus on the elements of internal coherence. The debate raised by this perspective is discussed and an explanation is presented on how the mainstream analysis was able to resist the critiques and translate itself into a coherent policy agenda. The alternatives approaches are reviewed, showing the lack of coherent framework. The article offers a epistemological point of view, since it shows that the reasons for the success are mainly rooted in the domain of competing scientific approaches.

Revisión crítica del debate tecnología-desigualdad

Palabras clave:
Cambio tecnológico
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R E S U M E N

En las últimas décadas del siglo xx ha habido un gran consenso sobre el efecto del cambio tecnológico en la distribución salarial. El núcleo de esta teoría se convierte en la columna vertebral de un paradigma científico que intenta dar una explicación a la mayor parte de las cuestiones abiertas en las actuales economías desarrolladas, desde el aumento de la desigualdad en desempleo de Estados Unidos a Europa, y de los diferentes patrones de productividad al cambio institucional. Se revisa el surgimiento de este conocimiento, así como el programa de investigación que lo consolida, con especial atención a los elementos de coherencia interna. Se trata el debate que surge desde esta perspectiva y se presenta una explicación de cómo el análisis de la corriente principal fue capaz de resistir las críticas y traducirse en una agenda política coherente. Se revisan abordajes alternativos, mostrando la falta de un marco coherente. El artículo ofrece un punto de vista epistemológico, desde donde se muestra que las razones del éxito se originan principalmente en enfoques científicos en competencia.

*Autor para correspondencia. Fundación Universitaria Konrad Lorenz, Carrera 9 Bis, N.º 62-43, Bogotá, Colombia.
Correo electrónico: francesco.bogliacino@gmail.com (F. Bogliacino).

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This paper reviews a large amount of literature over the analysis of wage distribution in the United States. Its main novelties stand in that it puts together three or four strands of literature that usually are kept distinguished, and also in that the bottom line is epistemological.

In fact, the last decades were the dawn of a transatlantic consensus in the academy (Atkinson, 2001) over the diagnosis, causes, and solutions for the raise of inequality. The seeds for this theoretical hypothesis are rooted in the debate over the role played by technology in shaping US wage distribution. This research program becomes from the very beginning a self contained paradigm, where the direction of investigation was that of the normal science (Kuhn, 1962), i.e. devoted to overcome the difficulties without questioning the assumptions over which the paradigm itself was built.

The main consequence was the ability to translate this theoretical framework into a discourse highly influential in the political debate, both in the US and in Europe. Even though the use of alternative frameworks of analysis is now widespread inside the literature and, as we will see, some of the critiques are actually decisive, no coherent and influential agenda emerged from them.

The paper is organized as follows: the following section reviews the prodromes of the normal science, the empirical analysis of the data based on the paradigmatic theoretical framework; section III describes the paradigm; section IV presents the critiques based on empirical problems; section V presents the alternative explanations advanced, and finally, section VI concludes.

The beginning of the story: some empirical analyses

At the beginning of the nineties, it was already clear that wage inequality was rising. Katz and Murphy (1992) analyzed data for the period 1967-1987, using a sample from March CPS. Using a standard Mincerian augmented human capital regression they tried to account for the facts in a standard demand and supply framework. The gender and the black-white gap, the most evident episodes of segmentation in the US labor market, were shrinking, but inequality was rising along other dimensions. The attention was captured by the educational premium, growing fast in the eighties, in a period in which the US, like all the other OECD countries, were facing a change in the composition of demand raising the educational level.

Topel (1997) shows that the share of college educated in the labor force jumps from thirty to forty percent in a decade (the eighties). At the same time, Katz and Murphy (1992) obtained that the skill premium decreased during all the seventies (they indicated a log change, multiplied by 100, from 1971 to 1979 of –10.4) and increased during the eighties (12.4 from 1979 to 1984). The total effect is positive (5.4 from 1967 to 1987). How can the two stylized facts, a raise in the relative wage and a decrease in relative scarcity, be reconciled?

In a standard demand and supply framework, as the one explicitly taken by Katz and Murphy (1992), the parallel increases in wage and supply can be justified only in presence of a demand shift. That paper put together as possible explanations the globalization with a specialization effect (favoring skilled labor intensive products), a possible preference evolution towards more skilled intensive productions generating a sectorial reallocation and finally a technological drift favoring educated workers (skill biased technological change, i.e. innovative activity favoring the relative productivity of skilled workers). They shared the view that a sort of long movement of labor demand towards highly educated labor was in place.

According to Juhn et al. (1993), the stylized facts should be correctly identified. In their words (Juhn et al., 1993:412):

> "Our conclusion is that the general rise in inequality and the rise in education premia are actually distinct economic phenomena."

As they said, there is a timing problem: the increase in within group wage inequality leads the increase in education premium by a decade. Secondly, the between group inequality seems to account for only one third of the overall inequality. Of course, since the setup is the same, they accepted a thesis of a demand shift favouring skilled workers.

The novelty of the picture was the contemporaneous presence of an increase in dispersion and a stagnation of the mean: a polarization of the labour market that was destroying the middle class jobs. According to Levy and Murnane (1992), which reviewed the literature over the eighties, this was the historical curiosum that drove back the attention over inequality.

A large strand of literature tried to pass from the description to the assessment of the alternatives. Bound and Johnson (1992), for example, used various measures to decompose the changes according to the contributions of tastes, trade, institutions, and technology. The latter was indicated as the main factor, but the explanation appears methodologically weak. The approach followed is that of treating technology as the residual, so weaknesses of other explanations immediately becomes its strength, but identification does not occur because of a standard problem of omitted variables. Quoting Bresnahan (1999), technology becomes a Rorschach bolt in which you can see what you want.

Apparently, stronger evidence in favour of technological determinants comes from some other studies: Berman et al. (1994), Berman et al. (1998), and Machin and Van Reenen (1998). The first one constrained the analysis to the US, while the other two analyze other OECD countries in order to control for different institutional frameworks, but all of them are limited to the manufacturing sector. This last choice has a positive and a negative consequence: on the one side it is possible to address explicitly the innovative activity, e.g. through measures of R&D expenditure, on the other side, it may raise problems of generalization.

Berman et al. (1994) assessed the role played by technology using both a decomposition technique and a standard regression framework. The authors are particularly interested in comparing the effects of trade and technical change. They suggest that the strong correlation between the within

industry skill upgrading and both R&D expenditure and computerization provides direct evidence of biased technical change. They suggested that evidence on the within industry skill upgrading can be seen as a signal of the presence of a skill biased technical change with a pervasive nature all around the industrialized world. Their line of reasoning is unclear: for example, they presented as empirical evidence in favour of skill biased technical change some case studies in which innovation is deemed to reduce unit labor cost, which is certainly a standard feature of innovation, but from which we cannot infer that innovation is raising the relative productivity of skilled labour (Howell, 1999). Even more important, Machin and Van Reenen (1998), Berman et al. (1994), and Berman et al. (1998) are all using the change in the share of non-production workers in the wage bill as a measure of skill upgrading, which may induce tremendous risks of measurement errors.

The theoretical background of these works presumes that technical change is affecting wage differentials through the presence of complementarity among capital inputs and skills, a setup that is now the orthodoxy to interpret the changes that are occurring in the US. Sample limitations are serious for many of the empirical exercises in support of this theoretical hypothesis. Berman et al. (1994) argue that both outsourcing and production workers are over-represented in manufacturing, thus inference is legitimate since manufacturing is an upper bound of what is happening in the rest of the economy. However, the dynamics involving the rest of the economy can be different and external validity can be minimal. The second point concerns the neglect of the supply of skills,* which seems to have a weight especially in the comparison between the US and the EU experiences; in fact some of the demographic structural facts are different (e.g. the arrival on the labor market of the baby boom generation has different timings).

Autor et al. (1998) are certainly one of the milestones for the technological explanations of inequality. Although very cautiously, they suggest an acceleration of skill biased technological change in the 1980s (but are dubious over a confirmation of the trend in the subsequent decade) and identify in the computer (as in the provocative title) the main factor beyond it. In their words:

> "Although the strong observed conditional correlations of computer measures and the growth in the relative utilization of highly educated workers may not just reflect causal relationships, it seems clear that whatever is driving the rapid rate of within-industry skill upgrading over the past few decades is concentrated in the most computer-intensive sectors of the US economy" (Autor et al., 1998:1203).

Another set of empirical research on the topic was inaugurated by Blau and Kahn (1996). This alternative approach is closer in spirit to the standard labor economics one, assuming a labor market nested into a complex set of institutions as opposed to the competitive assumptions of the SBTC models. Consequently with these different theoretical backgrounds the latter focuses more on differentials (which conveys the idea of market clearing wage), while the former has an emphasis on the overall distribution, as explicitly stated in their conclusions by DiNardo et al. (1996). According to Blau and Kahn (1996), the demand-supply movement seems not to be adequate to explain the global story (US and other countries). They suggest that unions in the US are less able to directly and indirectly (through spillover effects) reduce wage inequality and underlined the role played by mechanisms such as wage centralization.

DiNardo et al. (1996) try to assess the magnitude of the effects of de-unionization and minimum wage decline. The latter shows a striking downward movement of the eighties is striking, as shown by Card and DiNardo (2002). They used a semiparametric approach, based on Blinder-Oaxaca variance decomposition. This technique has been used by many labour economists and basically consists in building counterfactual variances that one would have observed if the suspected event had not existed. General equilibrium effects are excluded by assumption, e.g. DiNardo et al. (1996) assume that minimum wage is not affecting either employment or the distribution above the minimum wage threshold. Under these assumptions, institutional factors accounted for three fourth of the overall change (they investigated the period 1979-1988).

Regardless of the methodological critiques, there is a timing problem with their explanation: the reversal of the trend for the minimum wage in the 1990s is not consistent with the pattern of inequality observed (still growing at higher rate in the upper tail and stabilizing, but not reversing, in the lower one).

The 1990s saw also a flourishing literature over the role of trade, probably as a by-product of the rich research over the effects of globalizations. According to simple models of comparative advantages, increasing openness with low skill workers endowed countries pushes US and other OECD countries towards more skilled intensive productions. This standard mechanism is not completely consistent with the data. As Acemoglu (2003b) underlines, the skill intensive commodities prices should be increasing, while they are going downwards and the level of inequality in LDC is (counter-theoretically) increasing.

Feenstra and Hanson (1996) tried to capture the effect of outsourcing. Their story can work only for the eighties, but, as they suggest, probably there is a problem in their measure (which is built on intermediate inputs import and cannot really distinguish between simple intermediate inputs trade with other advanced countries and outsourcing). Feenstra and Hanson (1999) tried to compare computer investment and outsourcing in their effect over wage inequality. Their results are mixed, in the sense that changing the measure for computer investment the relative weight of the factors is not stable.

Finally, Borjas and Ramey (1994 and 1995) present some empirical support and also a possible theoretical explanation of the role of trade deficit in durable goods in explaining the education premium. Empirically, they use macroeconometric techniques showing that this series is the only one that shows

*This is explicitly recognized by Machin and Van Reenen (1998) in their conclusions.

a common stochastic trend with the wage differentials, but the out of sample predictions fail at the turn of the decade from 1980s to 1990s. Theoretically, they think that, given the high level of market power showed by the firms in the durable good sector and the high share of low skilled workers employed, an increase in competition can reduce rents acting as a downward pressure over wages.

In the 1997 *Journal of Economic Perspectives* symposium, the conclusions were neatly supporting the orthodoxy. Except for Fortin and Lemieux (1997), that strongly committed themselves to an institutional explanation in the flavor of DiNardo et al. (1996), the main conclusions in the analysis of demand and supply forces (Johnson, 1997; Topel, 1997) stated that the key role is played by technical change.

Skilled biased technological change

Developed to give an explanation to the empirical findings shown above, the skilled biased technical change (SBTC) hypothesis is a theory of directed innovation, i.e. affecting differently the factors relative productivity (in contrast with the standard neutrality assumptions).

The idea that innovation, instead of being neutral, can be induced to substitute or complement one of the factors dates back to Hicks (1932), but the general equilibrium models with SBTC are much more recent, since they have been developed in the nineties, building on the endogenous growth theory, *à la* Aghion and Howitt (1992). Its diffusion was noticeable outside the academy, where it

> "utterly dominated the discussion in the media and policy-making circles" (Snower, 1999).

What is the origin of the SBTC hypothesis? As we said above, the empirical literature that drove back the attention over wage inequality was competitive in spirit. Since in the periods under analysis both relative supply and relative wage of educated workers increased, taking as granted the assumptions, there should had been a relative demand shift.

The choice of technology as the main source of the above demand drift is due to the poor empirical power of alternative factors (mainly focused on changes between industries while the main variation occurs within), consequently raising the predictive power of the residual-shaped technical progress, but may have been influenced by the great debate in the public opinion related with the effects of information and communication technology (ICT).

From these first steps we can appreciate our claim about the normal science type of research. According to the Kuhn (1962)'s lexicon, once a paradigm is established in a science, for a long period, the effort of the scholars is addressed more to extend the empirical content and to realize internal coherence than to face the (unavoidable) weaknesses. We follow, for a moment, the logical path. In order to have a proof of the argument that only a demand shift can explain the increase in inequality, we need to reason by modus ponens: we should first prove the implication and then prove the hypothesis in order to deduce the thesis:

$$[[(p \wedge q) \rightarrow s] \wedge (p \wedge q)] \rightarrow s$$

where: p = perfect competition is in place and relative supply is exogenous; q = relative supply and relative wages increases; s = demand increases, but the reasoning proposed is:

$$[[(p \wedge q) \rightarrow s] \wedge q] \rightarrow s$$

which can be false. For instance, the above literature assumes perfect competition and exogeneity of the supply, but no argument is proposed to justify that perfect competition with exogenous labour supply is a reasonable description of the labour market.

We know, from the two introductions to Lindbeck and Snower (1988) and Akerlof and Yellen (1986), that at the end of the 20th Century a large portion of labour economics deviated from the competitive and market clearing assumption over wages, precisely because of the lack of empirical robustness of competitive assumption. However, there is also a more subtle ideological problem. It is along the edge between perfect competition and market power, where the distinction between the SBTC literature and the other potential explanations comes out clearly. At the opposite, the presence of institutions cannot be used as a *discrimen:* in fact, in order to enlarge the empirical and theoretical content of the theory, scholars have added institutional features in their models; but adding institutions as a contour to an unquestioned core is of course different from reforming the core itself.

What are the keys of this success? On the one hand, science is not rhetoric and there is indeed evidence technology has played a role in the transformations that occurred in the labor markets. On the other hand, there are some theoretical and practical appeals in this theory: theoretically, it is as simple as possible but not simpler, in the sense that it is a general equilibrium theory, with endogenized growth, but it is elegant, clear and transparent; practically, it captures a large part of the common sense and empirically documented facts about ICT and changes in firms recruitment practice and internal organization.

The analogy with the Kuhn (1962)'s concept of normal science can be used as a guideline also with regards to the subsequent development of the theoretical corpus of the SBTC. We will now discuss part of the highly prolific internal debate, and that part of the research program that extended the empirical content of the paradigm, which we will treat in the next subsection.

The internal debate

Originally, the SBTC appears in two versions that can be called endogenous and exogenous (the distinction belongs to Acemoglu, 2002a). Both leave the supply of skills out of the picture: according to Acemoglu (2002a), the supply changes is due to more structural factors, like the arrival of the baby boom generation, the Vietnam War Draft law and the increase in education expenditure by the Federal Government. Both

models are built over an acceleration hypothesis: the demand drift is supposed to have taken place in the last three decades of the 20th Century, driving the increase in relative wage. They assume that the channel of transmission is given by capital-skill complementarity: better machines are matched with higher skills, raising the relative productivity of the workers owning them. Empirical evidence of this phenomenon can be found in Goldin and Katz (1996) and Krusell et al. (2000).

The endogenous SBTC has been developed by Acemoglu in a series of influential papers (Acemoglu, 1998, 2002a, 2002b, 2003a, and 2003b) and others; the most original one is probably Thesmar and Thoenings (2000) for the stress on the organizational elements.

The model acknowledges the Neo-Schumpeterian Growth Theory *à la* Grossman and Helpmann (1993) and Aghion and Howitt (1992) for the setup and basic assumptions. It is a patent race model, included into a general equilibrium framework. Innovation occurs through R&D investment, and is spurred by profits incentives (the tribute to Schumpeter, 1942). Perfect patent protection guarantees monopolistic power over the production of the new vintage. Perfect competition is everywhere else. The structure of the economy is the following: an R&D sector at the top, in the middle two intermediate sectors and a final good sector (the aggregator) at the bottom, where technology is CES.

Into this setup, Acemoglu (1998) introduces an assumption, which is the cornerstone of the model. In the intermediate sectors, two goods are produced, one in which firms use only a certain type of machines together with high skilled workers and the other in which firms use only machines and low skilled workers. This scheme captures the idea of capital skill complementarity: the firms that do research can try to realize new vintages matching with high educated employees or, at the opposite, with the low educated ones. This scheme is a device to introduce a demand pulled innovation process.

Historically, the latter was proposed by Schmookler (1996): the pattern of innovation is supposed to be driven by the demand perceived by the firms, so it can happen that some innovations are introduced only very late, since immediately after their invention, no market is foreseen for them (e.g. for the railroads case).

What are the incentives that drive the research towards one or the other factor? Why do the new machines complement skills? On the one side, there is a relative price effect: the scarcer factor attracts higher marginal return; on the other side, there is a market size effect: the less scarce factor represents a larger opportunity to sell the machines.

In general equilibrium, for certain value of the elasticity of substitution, the second one prevails generating an overshooting change: an exogenous increase in the educated workers supply, which *ceteris paribus* tends to drive the relative wage downwards, spurs more skill-complementary-innovation raising the skill premium (more than compensating the supply effect).

We will not discuss the assumption over the elasticity of substitution, which is a pure empirical issue, some notes can be found in Acemoglu (2002a).

The alternative approach, the exogenous SBTC, includes, among the others, Galor and Moav (2000), Caselli (1999), Aghion (2002) Aghion et al. (2002), and Aghion and Howitt (1998: chapter 9). The reference models are less homogeneous, but a large part has (again) a Neo-Schumpeterian flavour.

There is a technological breakthrough in the economy, affecting many different sectors. This new technology is embodied in instruments that are largely skill specific, i.e. only people with a proper human capital composition can use the new machines. The larger the size of this type of labour force, the faster the transition of the overall economy from the old to the new regime (this intuition is due again to an old paper, Nelson and Phelps, 1966).

The historical subject of this revolution is the ICT, with the striking modifications over both organizational structure inside the typical firm and the recruitment and wage policies, with the tremendous effect in terms of capital price reduction (Gordon, 1990), but certainly also with its problems, like the computer that are everywhere except into productivity data (quoting a famous statement by R. Solow).*

We will linger on the approach *à la* Aghion and Howitt since it represent the workhorse for the rest of the literature. They use the definition of General Purpose Technology (GPT), taken from Bresnahan and Trajtenberg (1995):

> "A GPT is a technological breakthrough that affects the entire economic system, that is, most sectors in an economy" (Aghion, 2002:863).

But this literature has point of contacts with the conceptualization of the techno-economic paradigm, by the Long Waves-Evolutionary Theory (Nelson & Winter, 1982; Dosi, 1988; David, 1990; Freeman & Louca, 2001) and that of the regulatory regime, by the french Ècole de Régulation (Aglietta, 1976; Boyer, 1986).**

We claim that their approach is more complete in the sense that they don't assume the paradigm shift to be always directed towards more educated people, which is more historically pertinent given the unskilled labour bias of the First Industrial Revolution.

In Aghion and Howitt (1998), the pattern of diffusion follows the usual logistic pattern of the epidemiologists, and two steps should be completed in order to arrive at the production: (a) firms should realize a template to start experimentation, and (b) they should implement a workable routine on the template. The rate of arrival of (a) and (b) are Poisson distributed and there is a social learning process: the higher the investment effort, the faster the transition to the new regime. The main difference from endogenous SBTC stands in the source of the innovative incentives: it is the technology itself that through the social learning generates the new opportunities, a technology push.

The internal debate copes with the problem of harmonizing the obsessive focus on technology as the main if not the

*Gordon (2000) and Oliner and Sichel (2000), in a *Journal of Economic Perspectives* symposium debate about the same data getting exactly the opposite conclusion. To our knowledge, this is the best example of the lack of a univocal story about the ICT.

**Of course, the paternity issue does not make sense since the differences in the conceptual frameworks are so strong that they are barely comparable.

only determinant of the events, with the poor productivity performance (the productivity paradox) of the US until the second half of the 1990s. Acemoglu (2002a) defends his own approach invoking decreasing return to R&D, while Aghion (2002) quotes David (1990), that describes the difficulties faced in the introduction of technological breakthrough (like the steam engine) that sometimes took decades.

In an evolutionary perspective, the debate between demand pull and technology push is an old one and probably many scholars would argue that is missing most of the story (Dosi, 1988). Since this latter school sees technology as a path dependence, trial-and-error-mode, fundamental uncertain and trajectory related process, the two forces (the push and pull incentives) operate only once the appropriability and opportunities conditions are fixed (only at the margin). At the same time, in an evolutionary perspective the productivity paradox is not really a paradox! The time dimension to implement a new regime, the necessity to build the new machines (in a Hicksian perspective) and the uncertainty of the technology domain are all factors that justify a time lag before seeing the productivity raising. This poses against the edge between the normal science, where this reasoning cannot live together with the informational assumptions of the mainstream theory, and the out-of-the-paradigm research.

This tendency to avoid relaxation of the basic assumptions determines certain coherence in terms of policy implications. The explicit introduction of the anti-union climate of those years (explicitly recognized by some scholars, e.g. Acemoglu, 2002a), the change of social norms, or the difference between skill and education, or the existence of more than two types of skills (Atkinson, 2000; Howell, 1999) would probably lessen the coherence of the policy agenda of all this literature. In fact, as stated by Snower (1999:53):

> "There can be no doubt that the conventional preoccupation with supply and demand under conditions of perfect information and perfect competition has a strong laissez faire bias."

We can now make hints at two other minor debates internal to the paradigm.

First of all, there is not a consensus over the acceleration of the seventies versus a steady demand hypothesis. According to the former (to whom belong both the exogenous and the endogenous SBTC described above) the seventies saw a change in the pattern of the demand for skilled labour, while the latter propose a long run trend of increasing demand for skilled labour, with the movement of the skilled premium determined by the movement of the supply. Advocates of this latter approach are Katz and Murphy (1992), Card and Lemieux (2001) and Autor et al. (2005). This thesis is rejected by the accelerationists that insist on the computer argument and the change in the firms that have been induced* and the historical evidence over capital skill complementarity by Goldin and Katz (1996).

*Bresnahan (1999) and the empirical studies reviewed in section 2.

Secondly, there has been a discussion over the existence of a polarization. It has been recently proposed by Autor et al. (2003), Autor et al. (2005), and Autor et al. (2006) trying to defend the paradigm from the observation of Card and DiNardo (2002) and Gittleman and Howell (1995) over the differences in the tails of US wage distribution that we discussed above. Assuming (as in Autor et al., 2003) that computer capital is substitute for routine labour and *q*-complement for non-routine labour (computer raises the marginal productivity of non routine labour), such as problem solving, legal writing or communicative tasks, with the decline in ITC capital prices (the causal force) the marginal worker reallocate her supply from routine to non routine labour. The effect of computerization happens to be non monotonic, having a skill complementarity feature at the top of the distribution and a substitution one in the middle. According to Autor et al. (2006), at the beginning both effects operate, while in the second phase, since the decline in computer capital prices continue, once the substitution has been complete, the computerization affects only the top of the distribution.

Enlarging the paradigm

We want to conclude this section by showing how the supply demand technological change theory is structured as a self-contained paradigm. In the last decade, much of the theoretical effort was driven to incorporate new predictions (to increase the empirical content *à la* Lakatos, 1970) and coherence with new stylized facts, enriching the framework, but without weakening the core (Hernstein et al., 2005).* We can summarize what we claim to be the key assumptions:

1. Technology is the causal source of the change occurring in the labor markets.
2. Institutions can affect the direction of change but the main determinants are elsewhere, i.e. the economy under analysis is a demand-supply plus institutions economy.
3. The best framework is the most parsimonious: two factors of productions (skilled and unskilled labour) or three at most (adding capital), leaving aside heterogeneity.
4. Power is not part of the story, neither through principal-agent nor insider-outsider considerations.
5. There is no place for social norms, political climate or others or, when added, they are at most affected by technology and not the other way round.

We can now review some of these research efforts. The first road that has been pursued is the supply-demand plus institutions. In this case there is the intention to include them into the picture, but again the modelling is intended to have as the main determinant the technology, while the

*Again, we want to stress that this reasoning is epistemological, in the sense that we deal with the historical development of a theory not with intentional behaviour of a real hypostasis.

institutions operate only as a contour variable. The main interest of this line of research was to accomplish the goal of having a unified causal explanation for the data of the US and the European Union. These areas are sharing the same degree of economic development and integration, have many other similar features with regards to other socio-economic variables, but they show strikingly different stylized facts in the period under analysis (Europe has no deep increase in wage inequality except for the UK, higher unemployment rate in all the continental part, increasing profit share, all elements that we do not find in the US).*

The idea of adding institutions to have a clue about Europe has been favoured by the high consensus in the literature that the wage rigidities in the Old Continent are less employment friendly, although not very robust (Nickel, 1997**). A new consensus emerged over the hypothesis that European regulation made the unemployment rise after the seventies since it reduces the ability of the economy to adjust after the shocks that hit the economy. This hypothesis has been elaborated by Blanchard (1997), Blanchard and Wolfers (2000), referring to adverse labour demand shocks, and Bertola and Ichino (1995), where a general micro-economic turbulence occurs. It can easily be adapted to a technology shock as the adoption of ICT, as shown by Liunqvist and Sargent (1998). This thesis became famous as the Krugman's hypothesis, whose formulation can be summed up as follows: there is a technology shock acting to raise wage inequality in developed countries, but in Europe the wage compression friendly legislation limited it at the cost of higher unemployment.

Acemoglu (2003) develops a search model in which a radical innovation occurs and firms should decide either to adopt it or not and to direct it towards skilled or unskilled labour. In this context the minimum wage pushes firms to match the new technology with unskilled labour, raising their productivity above the threshold. Practically, technology is again the main force, but no SBTC occurs and unemployment and wage compression are observed.

Another road that has been followed is to introduce a slight modification into the model, specifically designed to capture a particular empirical elements. Acemoglu and Zilibotti (2001) and Acemoglu (2003b) provide an explanation of the different pattern of productivity in developed and developing countries, Acemoglu (1999) explains the decline in wages at the bottom of the distribution, using a search model with SBTC chocks, finally Aghion et al. (2002), developing previous work by Violante, account for the change in within group inequality, using a GPT model with segmentation.

Finally, a strand of the literature conserves the main set up, but work mainly through a redefinition of concepts. The model of the economy is almost the same, but what has been called technological revolution is now organizational revolution (obviously spurred by ICT). Beaudry and Green (2003) use a model of technological adoption (on a frontier in which two different organizational forms are available) to explain the differences (commented above) between US and Germany. Although quite elegant and innovative in the focus over the accumulation of physical capital*, the paper is indicative of what we said about the parsimoniousness. Although trying to explain the changes through the adoption of organizational forms, explicitly:

> "Remains agnostic regarding precise forces (e.g. institutions, supply changes, or political economy forces) that have led [the different patterns]" (Beaudry & Green, 2003:575).

Questioning the paradigm: empirical problems

There is a literature that runs parallel with the conventional wisdom illustrated above: its main scope is to face the weaknesses and in general the missing points of the mainstream explanation. Methodologically, a large body of empirical works makes it. As we will see, some of the critiques illustrate evident *aporiae* that are very difficult to avoid leaving the core untouched. Did this fact block the research program of the normal science? The answer is negative, and epistemologically, it is not surprising. In fact, all theories have problems, missing pieces, internal contradictions but once a paradigm is established, scholars have a guideline for research, a large body of questions to answer, a setup to work on. It is then more efficient to exploit the paradigm as much as possible, i.e. until an alternative paradigm is sufficiently developed. If this last claim is true, then making a large collection of empirical puzzles is important but cannot represent a strategy to develop an alternative theory. At the opposite, as shown by Feyerabend (1993), putting together confuted theories can sometimes be a more successful strategy than just writing a list of the situations where an explanation conflict with data.

Among the others, there was a bunch of papers that where openly discussed by the mainstream, which baptized them the revisionists (Autor et al., 2005). We refer to DiNardo et al. (1996), DiNardo and Pischke (1997), DiNardo and Lemieux (1997), Fortin and Lemieux (1997), Lee (1999), and Lemieux (2002 and 2006). They argue the following things: (a) the upsurge in wage inequality is rather episodic and we should be cautious in isolating any kind of trend; (b) the causal factors at work are mainly institutional, like minimum wage decline and de-unionization.

In Card and DiNardo (2002), we can see the series of the US minimum wage in real terms. It declined substantially and continually for all the eighties, with an abrupt inversion at the end of the decade and a consecutive stabilization. According to these authors, the downward trend allows inequality to emerge, and, together with de-unionization and the change

*We should keep in mind that a unified story for Europe is very difficult given country differences.

**Once put in the simplest form, the argument is obviously time-inconsistent, since regulation was there even in the sixties where European performance was above the mean. In general, Nickell shows that there are differences throughout Europe, while the level of regulation is quite similar, and in general that empirically the employment effect, if present, changes from one institution to the other.

*Whose role has been recognized by Beaudry and Green (2005) also for wage inequality in the US.

in skill composition, represents the main determinant of the empirical findings of 1980s.

Other papers addressed more specific points. Card and DiNardo (2002), for example, question the computer explanation since blacks, who on average are less likely to use computer than whites, are relatively gaining in the last part of the century. Using data disaggregated for the types of college degree, they show also that no significant premium exists for the computer skill graduated. Finally, they argue that an upsurge of inequality in the eighties seems difficult to reconcile with the ICT boom, which is a 1990s phenomenon.

DiNardo and Pischke (1997) object over the direction of causality. They show that pencil and other office tools are associated with higher wages as much as computer, arguing that it is not a treatment effect but a selection problem: workers with higher wages are more likely too use these tools on the job.

With regards to Card and DiNardo (2002), we believe that the first and the third critiques are not very significant: the black and white gap is shrinking because of the civil right movement and better access to school, while the timing problem is not a paradox if we accept the evolutionary perspective that the new machines need time to be completely understood and made workable. The timing objection can also be reversed. First of all, while the decrease of bottom wages and the increase in the 50th-10th differential are concentrated in the 1980s, as we said before, in the upper tail the upward trend continues also for all the nineties. In fact, when Lemieux (2002) proposes a unifying framework honestly admits that it does not work for the upper tail. Secondly, the lack of general equilibrium effects can raise doubts on robustness. In table 1 we summarized the main findings of their decomposition exercises.

The second set of works addressed presumed inconsistencies of the supply-demand plus institutions hypothesis as a means of explaining the differences between the US and the EU.

Snower (1999) shows that in OECD data there is not a trade off between inequality and unemployment; certainly, if a relation exists, at least statistically, it seems to be positive (Galbraith et al., 1999). If the Krugman's hypothesis had been true, Europe would have experienced an unskilled labour unemployment crisis; a prediction that is at odds with the measured unemployment rates, that are not significantly different through educational groups (Nickell & Bell, 1996; Nickell, 1997). Following the same line of reasoning, Europe should have experienced an increase in dispersion in the upper tail, which is again in conflict with data (Atkinson, 2000).

Howell et al. (2007) raise doubts over the "confidence with which it is concluded [...] that labor market rigidities are indeed at the root of poor employment performance" (Howell et al., 2007:50), given that the low magnitude of the estimated coefficients are deeply in contrast with the authoritative tone of the policy conclusion. In fact, many of these studies rely on poor quality data, and once better measurement of institutional variables have become available, the replication openly reverses the findings. For example, Howell et al. (2007) find a robust positive correlation only between unemployment and benefit generosity, but a Granger-Causality test argues in favor of the opposite direction, consistently with a political economy explanation (more demand for protection in presence of higher unemployment).

Finally, we discuss the findings of Piketty and Saez (2003) and Becker and Gordon (2005), giving emphasis to the top of the distribution. Although based on household (instead of individual) wage inequality, the main stylized facts are consistent with the standard ones.

The origin of inequality cannot be technological, say Becker and Gordon (2005), if "only the top 10 percent of the income distribution enjoyed a growth rate of total real income (excluding capital gains) equal to or above the average rate of economywide productivity growth" (Becker/Gordon, 2005:59) as it happened in the US. In general, the boom is "very large and concentrated among the highest income earners" (Piketty & Saez, 2003:34).

They conclude that the increasing share of the upper decile and the increasing skewness inside this decile accounts for almost all the extra income gains.

The subjects that benefited from these extra gains seem to be CEOs, whose compensation exploded in this period, also because of the stock options, that are included in the compensation for US accountancy rules. In figure 1 we confront the average wage together with those of the top 10 and top 100 CEOs. The ratio between the two is dramatically increasing. According to the authors, these types of job are very unlikely to be determined by technological factors, because of the bargaining power they have, since they are the only category which can fix its own pay, and because of the weight of social norms, ultimately, in fact: "executive pay is probably determined to a significant extent by herd behaviour" (Piketty & Saez, 2003:35).

Table 1. Quantitative effect of Institutions for the Wage Inequality in the US, various studies, all with semi-parametric approaches.

	Minimum Wage effect	Unions effect
	DiNardo et al [1996], period 1978-1988	
Men	25.00%	13.89%
Women	30.00%	11.11%
	Fortin and Lemieux [1997], period 1978-1988	
Men	24.20%	21.00%
Women	32.10%	0.00%
All	39.30%	10.30%
	DiNardo and Lemieux [1997], period 1981-1988	
All	22.00%	9.60%

Is there a coherent alternative story?

Let's start by stating that a negative answer should be given to the title of this section. On the one side, there is a genuine lack of consensus among the critical scholars, which also belong to different disciplines. On the other side, we should keep in mind that data argue in favour of a multi-causal explanation. In fact, it has been underlined that the upper and lower tails of the distribution seem to respond to forces that are partially

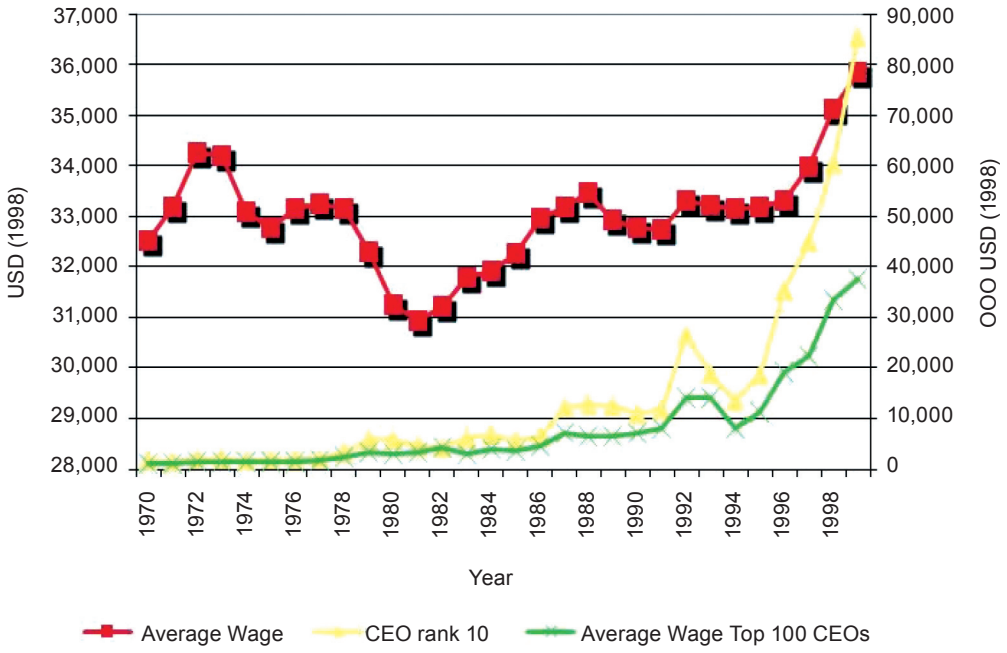

Figure 1 – Average and CEO wage, US 1970-2000.

different. While, in the former, we have a continuous increase all over the period and an increasing skewness towards the very top, in the latter, we have a decade (the eighties) of increasing dispersion and decreasing real wages and in the following decade a stabilization. At the same time, clearly we cannot assume that the top decile and the rest of the distribution between 50th and 90th percentile are shaped by the same forces, given evidence over the bargaining power of categories like the CEOs that are largely represented in the former.

The baseline of all these theory is the emphasis (a) over the residual inequality, which is no longer deemed to be a measurement error, but instead as the normal situation of an unavoidably segmented labour market; (b) over the problem of internal organization of the firm, in a framework which is more Coasian than Walrasian.

A possible alternative wisdom is the institutional perspective, based on the range theory of wages. According to this interpretation, proposed for example by Howell (1999), demand and supply, and through them the degree of international competition, technology, demography, and immigration can define only a large set of possible wage profiles, among which the choice is left to bargaining between firms and workers. The distribution of power between them is influenced by social norms, political climate and institutions. The change in fundamentals (globalization, massive migration and ICT boom) impact differently over skill groups, because of the decline in the sheltering power of institutions. At the same time, after the seventies there was a general redistribution of power, because of the abrupt change in the political climate —as an example, Howell (1999) evokes the Reagan's intervention in the PATCO strike—. There is also a theoretical conceptualization of this political revolution of the eighties, also called Neo-Liberalism: a normative system which considers the perfect market as the optimal institutional framework and tries to design both state interventions and governance systems in order to (re)produce its outcome (Harvey, 2005). As stressed by Foucault (2004), the Neo-Liberal State is not reducing its weight, but simply re-directing its effort from sheltering some social groups and redistributing, to correcting, creating, and integrating the real markets in order to move towards the ideal ones. There was a peculiar pressure over unions, because they were considered as the main pillar of the anti-competitive labour market of the Fordist system.* According to these authors, the Neo-Liberal thinkers see the battle to free the market as a fight to restore freedom.

Alternatively, we may think at a labour market where certain social norms concur as behavioural elements in the action choices of the parties involved. For example, wage policies that include redistribution among different groups of workers can be accepted as a social code; a change in the norms, such as more tolerance towards earning dispersion on the workplace can pave the way to an increase in inequality, because of less unionized plants or a simple generational effect (Atkinson, 2000). In a similar fashion, one can focus over an effect of the conflictual relationship of the seventies, that determines a restructuring activity by firms that hits different segments according to their bargaining power, damaging especially the unskilled workers (Sabel, 1982). There is also a large sociological literature in favour of a similar explanation. In particular, researches has been conducted

*See the already quoted PATCO episode, or the intervention of Mrs. Thatcher against the miners' strike.

over the behaviour of the big companies, that in the post II World War kept a cooperative approach with unions, but, after the 1970s shocks, joined small firms' aggressive stance (for example, in the battle for Right-To-Work Laws), since they were perceiving as a threat the lack of flexibility of the current system. Quoting from one of those:

> "By the 1970s, […] a changed world economy convinced [the multinational corporations] that confronting organized labor was necessary for business success: they joined with small and large local businesses that had pursued such anti-union activities" (Canak & Miller, 1990: 269).

It is a matter of facts that at the turn between the seventies and the eighties, large re-direction of investment away from unionized plants, where for example the employment shrank by 25% between 1979 and 1982 (Piore & Sabel, 1984).

Finally, the last body of research that can be quoted is focused on the reorganization of the workplace and the system of shop-floor relations. The technology is deemed to have played a role, but the microfoundation of the labour market is completely different, usually including power relations through insider-outsider or efficiency-wages models. This striking difference allows the ICT to have non monotonic effects.

Snower (1999) uses the term of organizational revolution to sum up the changes occurring: (a) in physical capital, with the new multiple purpose machines; (b) in informational flows, with the ICT; (c) in human capital, with a greater span of competence by the typical educated worker, and (d) in work preferences, with a stronger preference for variety by employees. According to this theory, the typical firm organization shifts from a tayloristic (high differentiation of task, pyramidal structured) to a holistic (customer oriented teams, network structured) one (Lindbeck & Snower, 1996, 2000), redefining the set of skills required by the market, and consequently raising the differential between the old-style and the new-style workers (Snower, 1999).

Skott and Guy (2007) choose instead an efficiency wages setup. In their paper, the new technology raises the monitoring ability by firms and the dispersion increases according to the abilities of groups to avoid control. This is in line with the evidence from UK social surveys (Green, 2006) that the new technology and the new organizational systems are perceived as both lowering the quality of job and effort biased, i.e. paying more but extracting more.

The intuition behind these models comes from a rich body of research from labour relations studies. Piore and Sabel (1984) and Boyer (1988), for example, describe the collapse of the Fordist system of regulation, perceived as inadequate in a changing global environment because it was relying too much on scale factors, neglecting the flexibility issue (Dosi, 1988), and show how the introduction of lean production occurred. Kelly (1990) stresses the role of the new philosophy of management, based on the reduction of the sources of conflict at the shop floor level, where also the words can be fundamental, e.g. the use of downsizing instead of firing, total quality management instead of increasing effort, means of feedback and development instead of surveillance.

Conclusions

In this paper we reviewed one of the most important recent economic debate, raised over the transformations occurring in the distribution of income in the US and the role played by technological progress. Originated by a simple hypothesis based on the trends emerging from Mincer equation estimations, in less than a decade this approach became a candidate explanation for almost all the phenomena that advanced capitalist economies are facing. It represents now a general interpretation of the events occurring ending in the political debate, especially in Europe, where it is now on the core of the agenda.

We analyzed US wage distribution along many different dimensions in the last three decades of the last century and we discussed the way in which the same data have been looked at. We reconstructed the theoretical background of all those works, showing that they share to the same basic roots. This is helpful if the objective is the understanding of the weight that this literature has in the policy debate. At the same time, we try to give an answer to the question that many scholars seemed to pose: why did it happen that so many precise and detailed critiques were not able to substitute the conventional wisdom? We used an epistemological perspective, arguing that only in a paradigm-related framework the above puzzle can be recomposed. We reviewed step by step the research program of the conventional wisdom, discussing the weakness, but showing the advantages of a coherent, simple and extendable setup, as those offered by the paradigmatic explanation.

We concluded with a detailed description of what Kuhn (1962) would have called the revolutionary science: the theoretical perspectives that questioned the core assumptions of the mainstream consensus. We claimed that the edge between the two theories runs along the different conceptualization of the labour market: competitive in the one case, shaped by power distribution in the second case. Inside the theoretical effort of those alternative strands of literature, we were not able to find a unique pattern, which implies the absence of a unified policy agenda.

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